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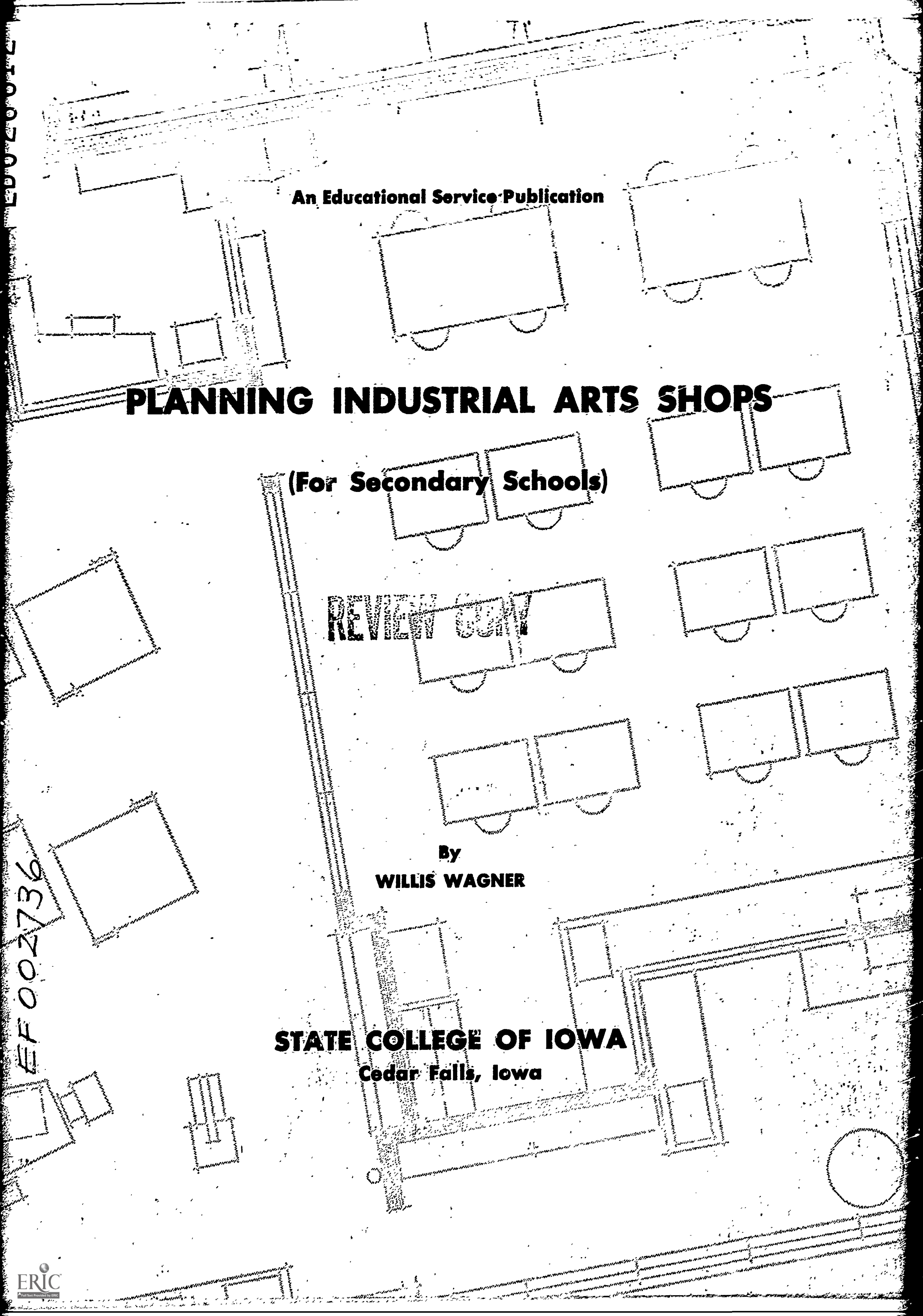
In addition to describing the usual considerations in facilities planning such as educational specifications, the role of the architect, the role of the consultant, this guide, intended for use by individuals responsible for industrial arts shops, focuses on those activities peculiar to industrial arts planning. The industrial arts planner, who may also be the instructor, should be responsible for his own educational specifications, equipment layout, and instructor's specifications. A statement of general standards and recommendations is included, as is a bibliography of books, manuals, and periodicals concerned with facilities planning. (FS)



An Educational Service Publication

PLANNING INDUSTRIAL ARTS SHOPS

(For Secondary Schools)

REVIEW COPY

By

WILLIS WAGNER

STATE COLLEGE OF IOWA

Cedar Falls, Iowa

PLANNING INDUSTRIAL ARTS SHOPS

(For Secondary Schools)

Educational Service Publication No. 31

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FOREWORD

The material developed by Willis Wagner represents an outstanding effort to provide a guide for the planning of Industrial Arts Shops. This book is important, since the shop provided will, to a degree, determine the quality of educational opportunities that can be offered.

The shop is the largest and perhaps the most important physical resource necessary for a good industrial arts program. Thus, it is essential that those responsible for plant planning understand the difficult task which confronts them. School officials, instructors, and architects who have the responsibility of planning industrial arts shops will find this manual a very valuable guide.

M. Gene Coffey, Ph.D.
Chief, School Plant Facilities Section
Iowa Department of Public Instruction

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Chapter I

GENERAL CONSIDERATIONS

Today our public schools face the greatest challenge in their history as they attempt to provide an educational program that will adequately prepare students for life in the country where industrial development and technology have reached the highest level ever known to mankind. Industrial arts is an important part of this educational program and contributes a range of experiences through which the student can acquire knowledge and gain appreciation concerning industrial tools, materials, processes, products, and occupations.

Direct experience in working with tools and materials results in the development of basic skills and is especially valuable in establishing efficient and safe work habits. The "real life" activities in the school shop also provide an environment in which the student can develop self-confidence, cooperative attitudes, and desirable character traits.

The problem-solving situation that predominates in constructional activities provides excellent practice in analytical thinking and the opportunity to make practical application of the principles learned in science and mathematics. Furthermore, the ability to read working drawings and to develop and record ideas through basic drafting skills is extremely valuable.

It should be noted especially that industrial arts provides educational experiences that are useful for all students, whether they enter industrial occupations, seek additional training in the skilled trades, or prepare for the work of a technician or engineer. These experiences also apply to avocational activities and the wise selection, care, and use of the vast array of consumer goods produced by our modern industrial technology.

Importance of Facilities

Carefully designed and well-equipped shops and laboratories are essential for modern industrial arts programs. An expert instructor, presenting well-organized and accurate course content, will not be able to attain the desired outcomes if physical facilities are not available. In order for the student to gain acceptable and worthwhile experience in constructional activities and solve problems in the area of research and development, work stations and supporting facilities must be effectively organized and adequately equipped.

Educational planners and architects are confronted with more complicated problems in designing facilities for this field of study than for any other type of offering in the general education program. Space for the various activities must be properly allocated; relationships between the activities must be recognized and the best arrangements devised; traffic patterns between work stations and supply centers must be studied; and provisions must be included for storage and control of equipment and materials. Special consideration may be required in the area of heating, ventilating, lighting, power, dust control, and acoustics.

The best and most satisfactory solution to this multiplicity of problems is most likely to emerge when there is close cooperation between the instructional staff, school officials, and the architect. Current practice suggests that the industrial arts instructor and/or supervisor prepare the educational plan and then develop the specifications upon which the architect can base his design. After the architect prepares the initial design, they can provide further assistance by developing an equipment layout and certain other detailed requirements.

Types of Shops

The size of the school, grade levels, objectives of the program, and financial resources of the community will largely determine the type of industrial arts facility selected for a given school. Basically there are three types of shops: the comprehensive general shop, the general unit shop, and the unit shop.

The *comprehensive general shop* provides facilities that represent a number of broad areas of industrial activity. Usually four or five major areas are included: for example; drawing, metalwork, woodwork, electricity, and power mechanics. Students work in all areas simultaneously under the direction of a single instructor. It is the type that will most nearly fill the needs of the small school where the industrial arts program is limited to a single shop taught by one instructor. A comprehensive general shop can provide adequate facilities, especially at the junior high level where the program is exploratory in nature. For advanced courses at the high school level, the lack of space and equipment may place some limitations on the opportunity for students to specialize in a given area.

The *general unit shop* provides for activities in a single basic area such as drafting, woodwork, metalwork, electricity, or power mechanics. An example might be the general metal shop where facilities would support work in sheet metal, bench metal, forging, foundry, welding, and machine tools. It is the type best suited for large high schools where four or five shops are required. General unit shops may be used to provide exploratory experiences in large junior high schools by rotating the students through the various shops on a group basis. In the senior high school, a well-planned general unit shop can provide a wide range of experiences in a broad activity area and also permit a high level of specialization in subdivisions of the area.

The *unit shop* is limited to work in a single major industrial occupation. Examples would include welding shops, sheet metal shops, machine tool shops, upholstery shops, and cabinetmaking shops. The work is highly specialized, and shops of this type are usually found only in very large high schools and vocational-technical schools. Unit shops are sometimes shared by advanced classes in industrial arts and regular classes in trade and industrial education.

The needs of the medium-sized school can best be served by still another type of shop sometimes called a *modified general shop* or a limited general shop. The total industrial arts facility consists of two or three shops, each organized to include two or even three major areas of activity. When possible, the combined areas should have some common characteristics and requirements. Examples consist of metalwork combined with power mechanics or electricity; woodwork with drafting or electricity; drafting combined with graphic arts; and electricity with power mechanics or auto mechanics. Usually each shop is assigned to a single instructor who has specialized training in the areas concerned.

The selection of the type of shops and areas of activity, the development of the curriculum pattern and levels of instruction, and the determination of class size and course content will require a great deal of study. Decisions should be based on facts and figures concerning state recommendations, school enrollments, type of community, probable growth, technological change, and national trends in industrial arts programs. All of this is referred to as educational planning and should precede the development of educational specifications and other phases of planning the industrial arts shop.

Chapter II

PRACTICES AND PROCEDURES IN SCHOOL PLANT PLANNING

The construction and operation of a school building is primarily the responsibility of the community which it will serve. The local school board, as an agency of the state, has the responsibility of satisfying the local educational needs within the framework of school laws and with the aid of consultative service furnished by the State Department of Public Instruction. Figure 2-1 shows the position and responsibility of various groups and agencies at the local, county, and state levels in the development of school building plans.

The function of the board of education in matters of school plant planning is the same as with all phases of school administration, e.g., the formulation of policy and the execution of decisions agreed upon. The superintendent, as the chief executive officer of the board of education, is the key individual in all aspects of the planning operation. It is his responsibility to coordinate the activities of all individuals and groups to the end that the most efficient use will be made of all resources in the development of a school building that will house the best educational program for the community.

It is considered good procedure and is becoming common practice for the superintendent to secure the assistance of his instructional staff in the planning program. Members of this group are usually qualified and highly interested in making extensive recommendations concerning their individual teaching specialty.

Here is the point at which the industrial arts instructor enters the planning project. Certainly, he will be the best qualified person in the local situation to plan and recommend the specific needs concerning the industrial arts program. He must work directly with the superintendent, or individuals appointed by the superintendent to represent him, in the total school planning program. However, because industrial arts instructors have considerable background in general planning and construction activities, there may be a tendency for some to overstep their bounds and assume undue authority in the planning activities. This does not mean that the instructor should refrain from offering any service of which he is capable, but rather that he continually recognize his responsibility and relationship to the superintendent and other members of the instructional staff.

Major Steps Defined

The total process through which a new school building comes into existence contains many steps, beginning with the initial study of educational needs and ending with the final acceptance of the new structure by the board of education. The planning for this total process is referred to as school plant planning, sometimes shortened to just "school planning." It includes such steps and subdivisions as surveys of the community and existing buildings, site selection, district reorganization, educational planning, and architectural planning. In modern times it is the total scientific study of the need of a school building program and the plan through which these needs may be fulfilled.

Educational planning follows after certain basic decisions have been made concerning the divisions and facilities that the total educational program of the school plant should include. It involves an extensive study of every activity that will be housed in the new building to the end that the most efficient plan for the physical facilities can be developed. The major focus in educational planning is on the school program. It is an aspect of school administration rather than a branch of architecture, and therefore the members of this planning staff should be educators by preparation and experience.

> "The planning of a specific new building breaks down into two parts, one primarily educational in nature and the other dealing with the architectural and engineering aspects. For the most part, the educational phase of the planning precedes the architectural and engineering phases, and provides the essential educational specifications upon which the architect and engineer base their proposals as to design and construction. The educational planning staff analyzes the school program to determine the number and nature of the physical facilities required; the architect and engineer

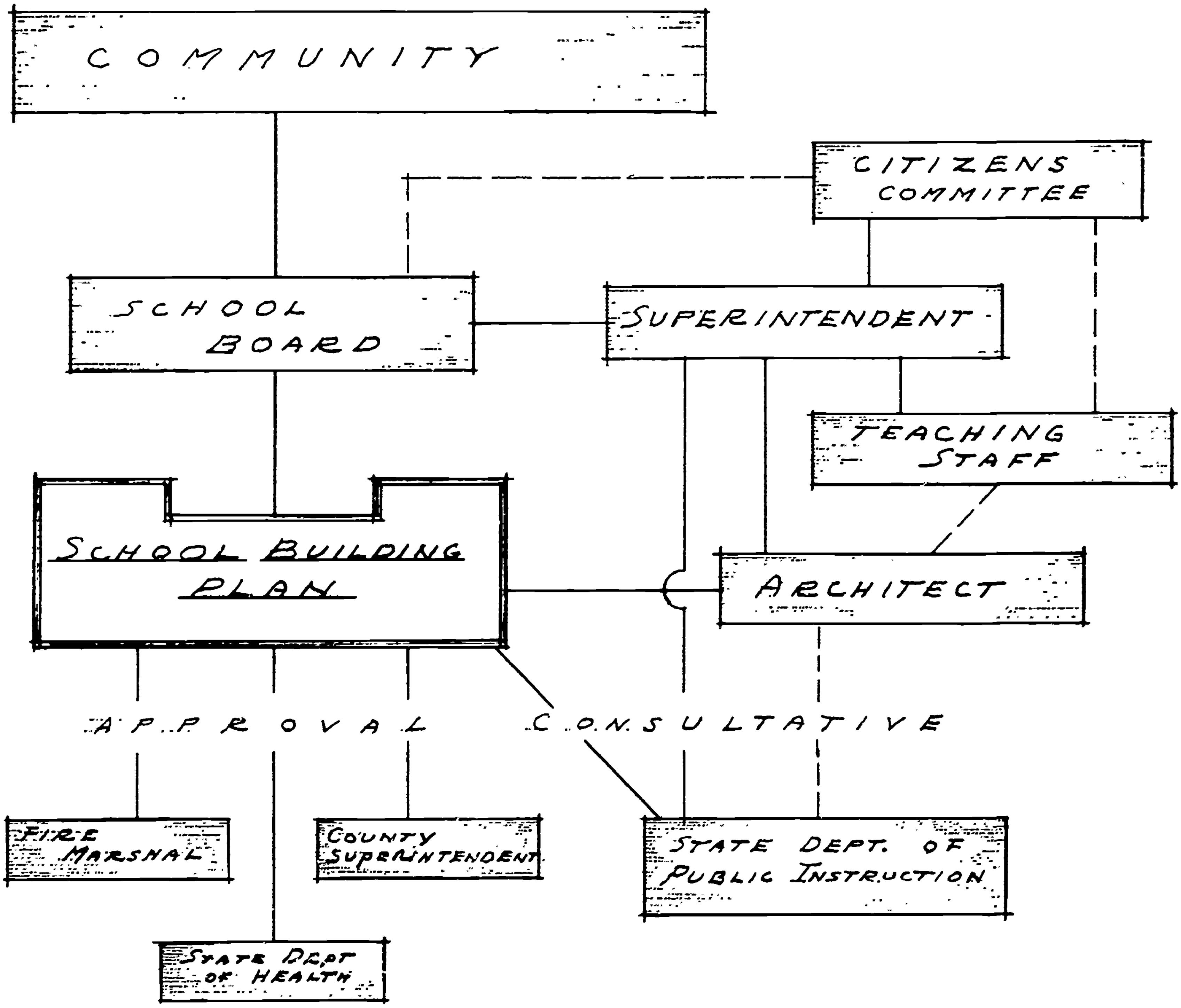

Fig. 2-1 Relationships and responsibilities in school plant planning (for Iowa).

then proceed to design a physical plant that will provide the needed educational facilities as well as satisfying certain important non-educational requirements."(I)

The *educational specifications* is a formal list of building requirements that is developed through the educational planning process and is the material upon which the architect and his staff develop their design. This written document is submitted to the board of education for approval and then transmitted to the architect to serve as his instructions with respect to the planning of the building. If the educational specifications are to result in the best architectural work, then they must be based on thorough and complete educational planning so that changes in them will not be necessary after architectural designing begins. These specifications should be clear, concise, and easy to understand. They should also be as free as possible of fixed requirements that will tend to stifle the creative imagination of the architect.

"The most valuable thing which the board of education buys in employing an architect is his creativity — his ability to comprehend a complex problem and then create an architectural solution that satisfies in an imaginative way the many and varied aesthetic, technical, functional, legal, and financial requirements of the project. *This creativity is most likely to emerge when the educational specifications are restricted to a statement of needs, without prescribing how these needs should be met.* Rigid requirements as to size of room, details of room

(I) Herrick, John and others, *From School Program to School Plant*, Henry Holt and Co., New York, 1956, page 105.

layout, or style and arrangement of buildings tend to stifle creativity and to reduce the architect to the status of draftsman and specification writer. Thus they deprive the board of education of the architect's most valuable contribution to the project."(II)

The Educational Consultant

Because the planning of a modern school building is such a complex problem, it is becoming the practice of school boards to hire an educational consultant in addition to an architect. He is a throughly trained professional educator with extensive experience in problems of school plant planning. There are a limited number of educational plant consultants available, and in some situations it may be more practical to secure the services of several different individuals who are experts in their various specialized fields. Such assistance can be extremely valuable in planning facilities for the curriculum areas of homemaking, agriculture, music, physical education, and industrial arts.

State departments of public education and colleges and universities that support programs in teacher education are usually able to provide educational plant consultants as well as those in specialized areas.

It is important that the services of the educational consultant be secured for a period long enough to be effective, starting with the various surveys, following through the educational planning and preparation of the educational specifications, and continuing until the time that construction is begun. For example: The assistance of an industrial arts consultant will be limited to merely that of arranging or selecting equipment and other minor details if his services are not secured until after the architect has developed his design.

The Architect and His Services

During this educational planning the instructor, administrator, and planning consultant play the leading roles in the total planning operation. After the educational specifications have been prepared, the architect takes over and remains the most important person until the building is completed. He develops the physical form of the educational specifications.

The architect has the background and experience to understand the requirements, recognize the problems, and develop the design. He organizes the space and creates the visual form of the building. He also recommends the materials and methods of construction that will provide the environmental conditions prescribed by the function.

Today the design of a modern school building is a highly complicated project, and the complexities are increasing. Educators and school patrons are demanding better and more effective solutions to meet the educational needs, and new developments in science and technology are extending the range of materials and methods. The architect must not only organize and arrange space to fill certain functional and aesthetic requirements, provide for efficient circulation and develop an over-all pleasing appearance, but he must also solve technical problems in the area of plumbing, heating, ventilating, lighting, and acoustics. In all his work he must follow certain guidelines established by the educational specifications, budget restrictions, building codes, and standard practices within the building trades and industries.

To the architect, every new project offers a challenge to create a structure that will satisfy the functional requirements and make a contribution to good architecture. To do this he must have the cooperation of all concerned. If faced with unreasonable demands and needless interference, he cannot do his best work. Obviously, he cannot exert his creative ability, imagination, and artistic skill if he is told exactly what to do. For satisfactory results, the relationship of the school board, superintendent, architect, and industrial arts instructor must be based on mutual trust, respect, integrity, and full cooperation.

Planning Sequence for Industrial Arts

As already indicated, the total building program from the initial surveys to the time the building is equipped and occupied is a complicated operation and may extend over a considerable period of time. There are certain steps that should be followed by those planning the industrial arts program. These steps are not entirely separated, but their sequence is rather definite and should be given careful consideration. They are listed and described briefly here with a more detailed study included in other sections:

1. **Develop the educational plan for industrial arts.** This must come first — it is the basis for all future decisions concerning the physical facility. It should be developed after

(II) Ibid.

a careful study of the needs and limitations of the local situation.

2. **Prepare the educational specifications.** After the educational plan has been completed, a list and description of the various facilities necessary to carry out the plan can be prepared. They must be clear, concise, and may need to be adopted to forms prescribed by the central planning committee. Include quantitative as well as qualitative requirements. A list of the major machines and other equipment will often aid in describing the physical requirements to the architect.
3. **Develop an equipment layout.** Working from the educational specifications, the architect will prepare the preliminary drawings. The industrial arts teacher should study these carefully to see if his educational specifications have been properly interpreted and followed. He should immediately proceed to develop an equipment layout. This will serve as a check to determine if the size and shape of the industrial arts shops can be effectively utilized. After the preliminary drawings have been approved by the board of education, a carefully scaled drawing showing the position and sizes of all equipment and fixtures should be prepared and submitted to the architect. In addition to this equipment layout, it may be necessary to prepare detailed drawings to describe special built-in features.
4. **Prepare instructors' specifications.** This will attach to the equipment layout and will consist of certain written information that the architect will need for the preparation of working drawings. They will include such items as electrical requirements for machines, suggestions for floor and wall finishes, special lighting, and recommendations for cabinet and fixture work.
5. **Equipment selection.** Although listed last, the matter of equipment selection must be considered and some major decisions determined throughout the planning sequence. Consideration of the cost of the equipment must be included in decisions concerning the educational plan. Types and sizes of equipment must be determined as the equipment layout is developed. This final step, however, includes the formal listing of all equipment — both hand and machine tools — with specific requirements concerning the make, size, design, and finish.

Chapter III

PREPARING THE EDUCATIONAL SPECIFICATIONS

The educational specifications describe the physical requirements through which the objectives of the educational program can be most effectively obtained. They consist of a written document prepared by the educational planner and are used by the architect and his staff as they develop the design for a new school building.

> "— If the educational specifications are to promote better architectural work, it is necessary that they be clear and concise, easy to use, and free of fixed requirements that stifle the creative imagination of the architect as he strives for the best solution to the problem at hand."(I)

In so far as possible the educational specifications should include all the essential information the architect will need. This, however, should be considered only as a goal, for there will be many occasions when oral explanations and discussions will need to supplement these written materials. It is good practice to provide a written record or memorandum of these conferences when they result in important changes or additions to the original material.

Educational specifications for an industrial arts shop should be prepared by the instructor with assistance, when needed, from the educational consultant. The material should include the following divisions: total recommended floor area; largest class size, and daily and weekly student load; description of the instructional areas and the number of individual work stations required; description of auxiliary areas; relationships and possible orientation of the various instructional and auxiliary areas; combination and multi-use of space; and future additions and alterations.

Total Floor Area

This figure includes material and supply storage, and other auxiliary space in addition to the instructional area required. It will vary for a particular shop and depends upon the age of the students, level and type of work, methods of instruction, type of shop organization, and class size.

Total floor area can be estimated by using area-per-student allotments. The table below lists the *minimum* floor area recommended for each student in various general unit shops that provide for a class of 20 or more students. Allowances for auxiliary space has been included in these figures.

	Senior High School Sq. Ft.	**Junior High School Sq. Ft.**
Drafting	65	55
Metals	90	80
Wood	95	80
Electricity	80	70
Graphic Arts	75	65
Power Mechanics	100	90

Minimum area allotment for each student for classes of 20 or more.

The floor area for comprehensive general shops can be calculated by using an average of the figures for the activity areas that will be included *and adding about one-third more.* This additional space will provide the flexibility that is so important when work in a number of different activities is in progress at the same time.

If these figures were applied to a comprehensive general shop that included the areas of drawing, wood, electricity, and metal, it will be found that the per-student-allotment is 110 square feet. If the largest class was limited to 24 students, the total floor area required would be about 2700 square feet. These figures should be considered as approximate minimum recommendations, and good judgment must be used as they are applied to a specific situation.

There is thought to be an upper limit to the size of a comprehensive general shop that can be effectively controlled and maintained by *one* instructor. Authorities in the field of industrial arts feel that the total shop size should seldom exceed 3200 square feet.

(I) Herrick, John and others, *From School Program to School Plant,* Henry Holt and Co., New York, 1956, page 108.

Student Load

The proposed student load is an important part of the educational specifications. The architect will need these figures as he analyzes the total floor area and determines the number of lockers, lavatories, drinking fountains, and toilet facilities located in or near the shop. These figures should be expressed in terms of the largest proposed class and the number of classes per day. If some classes do not meet daily, then the total number of individual students using the shop during the week should be given.

Description of Instructional Areas

The broad activity areas of the comprehensive general shop will vary considerably in basic requirements, and each one should be described separately. For some general unit shops, an explanation of certain subdivisions of the instructional area should supplement the description of the general activity. These descriptions should include such items as: approximate floor area required; a brief description of the activity; the number of individual work stations; important supplementary work stations and/or major equipment; special requirements for such items as lighting, sound control, dust control, and ventilation; and storage requirements. A sample description of drawing and planning area for a comprehensive general shop is listed below.

Drawing and Planning (area description)

1. Provisions for beginning and advanced work in the common divisions of drafting; including instrument work and freehand sketching. Also provide facilities for project planning and study, and presentations with audio-visual aids.
2. Approximately 800 square feet of floor area required.
3. Provide for 12 single station drafting tables and 8 project planning stations. The latter may consist of stools or chairs around standard 30-inch tables. The planning area should be adjacent to reference books and other resource material.
4. Provisions for drawing reproduction equipment, preferably located in an alcove and adjacent to a work table or counter top.
5. Include built-in shelving for library and reference books, adjacent to the planning area.
6. Provide a lavatory for handwashing and equipment cleaning.
7. Provide built-in cabinets for drawing supplies and flat files for storage of drawings in progress.
8. Include built-in storage space for motion picture projector, overhead projector, slide projector, and tape recorder.
9. Lighting for work in this area must be of the highest quality. Include provisions for lighting control that will permit the use of visual aids.
10. Area should be centrally located and separated from noise and dust of the main shop by glazed partitions. The entrance to this area should be somewhat near to the main shop entrance.

Auxiliary Areas

Auxiliary areas include such items as the instructor's office, finishing room, demonstration area, stock room, supply storage, project storage, and display area. The description may suggest the approximate floor area, requirements for special lighting, character of the activity involved, and suggested location in relationship to other areas. When describing storage facilities, include the amount and kind of material to be handled. A sample description of a finishing room and instructor's office is listed below.

Finishing room

1. Provide for the application and drying of finishes for wood and metal products. Methods of application will include both brushing and spraying. Since most projects will be small, a bench-type spray booth may be satisfactory.
2. Total room size should be about 250 square feet. It should be adjacent to the main shop area and separated by a glazed partition.
3. Provide at least 4 hand application work stations and about 50 square feet of drying shelves.
4. Provide fireproof storage for finishing supplies; both bulk storage and working stocks.
5. Include a lavatory with an adjacent work surface.
6. Finishing operations require especially good lighting and ventilation.

Instructor's Office (Control Center)

1. A separate room is preferred; however, if space is limited, this facility could be included in the drafting and planning area.

2. It should be centrally located and somewhat near the main shop entrance — about 90 square feet of floor area required.
3. Separate this area from the main shop with glazed partitions. From this center the instructor must be able to maintain a high level of visual control of all instructional areas.
4. Provide for a standard office desk, several chairs, filing cabinet, storage cabinet, and small bookcase. Also provide closed shelving and work surface for preparing instructional materials and examinations.
5. Include a small built-in closet for the instructor's personal effects.

Relationship and Suggested Orientation of Areas

Some industrial arts activities have similar requirements with respect to tools, materials, and work stations. These relationships should receive special attention when locating the areas, especially in the planning of a comprehensive general shop. The industrial arts instructor-planner should include in the educational specifications suggested patterns of orientation that might be based on such considerations as the following: Woodworking benches can be used for sheet metal layout; sheet metal equipment can also serve the electrical area; tools in the general metals area could supplement those used in power mechanics; and the fabrication of plastic products can be accomplished at many of the wood or metal work stations. In addition to the utilization of equipment, such factors as dust, smoke and fumes, noise, and light must also be considered in grouping the various activities.

Detailed analysis of these considerations will also be important later in the planning sequence when equipment layouts are developed.

Multi-use of the Industrial Arts Shop

The ever-present emphasis on economical planning due to high building costs and limited financial resources will require that the industrial arts teacher propose any multi-use of space wherever it is practical. For example: Stage-craft classes could expedite their work through the use of power equipment in the woodworking area; art classes might be scheduled in the shop to construct some of their three-dimensional studies; home economics classes could utilize the shop while covering units on electrical repairs or refinishing of furniture; and adult evening classes would find the well-equipped industrial arts shop an excellent facility.

Other examples could be cited; however, it might be well to suggest that such use of space can be extended too far. In the industrial arts shop there are important factors of maintenance, upkeep, and control that may reduce the desirability of such arrangements. The industrial arts instructor should strive for a high level of space utilization and should suggest possibilities for multi-use wherever they are feasible, but he should at the same time guard against proposed combinations that may become unsatisfactory and impractical over a period of time.

Planning a school shop that will be shared by industrial arts and vocational agriculture classes has generally proved to be unsatisfactory. The objectives, type of equipment, and kind of materials are considerably different for these two fields of work. The situation is further complicated because it is necessary to have a different teacher for each program. Usually, a school that is large enough to support both programs has sufficient financial resources to provide separate facilities.

When plans include the scheduling of other than regular classes in the shop, special provisions for their activities should be included. For example: If the shop will be used for adult evening classes, then provisions should be made for such items as excellent artificial lighting and extra project storage space. It will be important to inform the architect of any multi-use proposals by including them in the educational specifications.

Future Additions and Changes

If the educational planning has been adequate and complete, then it has given attention to the possible direction of expansion and revision in the instructional program beyond the immediate goals. The industrial arts instructor must convert this "forecast" into building needs that can be satisfied through conversions, changes, or additions to the proposed building. The architect, more than anyone else, will appreciate the fact that change is inevitable and will desire information of this type as he plans a building that has high factors of flexibility and expansibility.

Chapter IV

PRELIMINARY DRAWINGS

The educational specifications prepared by the industrial arts instructor should be organized with those of other departments and the total document presented to the board of education by the superintendent, with his special advisors available to answer detailed questions. After formal board approval, the specifications are transmitted to the architect who translates them into a design for the new school building.

The design of the new building will emerge in gradual stages, as the architect explores the various possibilities. Many different schemes are developed, tested, and modified or discarded until a satisfactory solution is found. The architect may, on some projects, prefer to present his early diagrammatic sketches to the educational planners before completing the preliminary drawings.

Preliminary drawings consist mainly of plan views that show the size and shape of space allotments, orientation of areas, circulation patterns, doors and windows, and special features. They quite often include a front elevation and a typical section that will show ceiling heights and general methods and materials of construction. Some architects may also include a perspective sketch that will provide the board of education and educational planners a view of the general appearance of the building. From these drawings the educational planners will be able to study the architect's design and check to see if the requirements listed in the educational specifications have been properly interpreted.

When the architect presents his preliminary plans to the educational planners (or when they are passed down the line from the board of education), the industrial arts instructor should immediately begin a study of the proposal for industrial arts to see that all requirements originally specified can be met. Some architects will show a few major pieces of equipment in their preliminary shop plan to indicate the basic pattern of their proposal. This equipment layout should be extended to be sure an ideal arrangement can be accomplished within the confines established. After the preparation and analysis of this initial equipment layout, the educational planner (industrial arts instructor) will be prepared to make helpful suggestions to the architect as the preliminary drawings are revised and reworked.

This is a *very important stage* in the total planning sequence and requires a careful and precise study to insure that all aspects of the program can be provided. After these drawings are approved, the basic plan and type of construction will have been established and it will be difficult to secure changes or adjustments.

As soon as the preliminary drawings have received formal approval by the board of education, the industrial arts instructor should immediately prepare a finished drawing of the equipment layout and detailed sketches of special built-in cabinetwork or equipment. This should be reviewed by the superintendent and then submitted to the architect. Attached to these layouts and drawings should be a list of "instructor specifications" which will furnish further information concerning electrical, water, and gas outlets, special plumbing requirements, ventilating hoods, built-in features and other items — all of which will be important information that the architect will need as he prepares the working drawings and specifications.

Chapter V

MAKING AN EQUIPMENT LAYOUT

Working from the architect's preliminary plans, the industrial arts instructor-planner should draw a floor plan (usually scaled one-fourth of an inch to the foot) that will show walls, partitions, doors, windows, and any special features. The plan should then be carefully analyzed with regard to the major divisions and the environmental characteristics. This will include a check of each instructional and auxiliary area to see that requirements for lighting, sound control, dust control, waste disposal, ventilation, and utility services can be provided.

As decisions are made concerning the location of major divisions, a detailed arrangement of equipment within the divisions can be developed. Some planners prefer to make scaled "cut-outs" or templates of each piece of equipment, which they arrange and rearrange on the scaled drawings as they seek the best solution.

Machines, benches, and other items of equipment can be represented with squares, rectangles, circles, and other shapes. It is important that they be drawn to exact scale and include a descriptive name. To add some definition to the graphic form of a given piece of equipment and insure that the operator's position is easily recognized, simple details may need to be included. For example: The operating position of a table saw will be evident by simply adding a short line representing the blade and another line across the table representing the rip fence. Other examples are shown in Figure 5-1. Some planners prefer to use an arrow to indicate the place where the operation is performed.

The relationships of the instructional and auxiliary areas which were recognized in the basic orientation and described in the educational specifications must now be considered in arranging machines and equipment. For example: Woodworking machines might be located near the lumber storage area to minimize traffic; a drill press or grinder could be used for the wood and metal and might be arranged between these areas, while welding benches, forges, and blast furnaces should be grouped together so that hooding and duct work can be unified.

When arranging equipment, it will be more realistic if the planner would think in terms of arranging student work stations. These work stations can be classified as individual or supplementary. The *individual work station* is one where the student may be employed for a considerable length of time and is often considered to be his "headquarters" during his experience in a specific area or while he is constructing a particular project. Benches, drawing tables, welding booths, lathes, and foundry benches are examples of individual stations and are usually assigned to the student. *Supplementary work stations* (also referred to as general work stations) are those where the student may be employed for only a short period of time and which supplements and augments the work being performed at the individual station. The grinder, circular saw, blast furnace, pouring pit, electrical test panel, and power hack saw would be examples of this type.

Since the major amount of the student's time will be spent at individual stations, they should be rather evenly distributed throughout the shop. It is also important to give the most consideration to individual stations when calculating the maximum student capacity of the shop. A tabulation and analysis of the supplemental stations for a given shop indicate the variety of activities that are available and the possibilities for specialization.

As an equipment layout is prepared, consideration should be given to the *basic principles* listed below:

1. All work stations must include sufficient floor area for the equipment and *for the student*, so that the operations can be performed without interference from other work stations or shop traffic.
2. Hazardous work stations and equipment should be "pocketed" and otherwise protected to isolate the worker and to insure safety to other students in the shop. It is usually best to locate these stations at some distance from the main entrance and away from major traffic lanes.
3. Arrange equipment so that the material being processed will not interfere with other work stations or shop traffic; for example: cutting long lengths of stock on the radial arm saw or power hack saw.

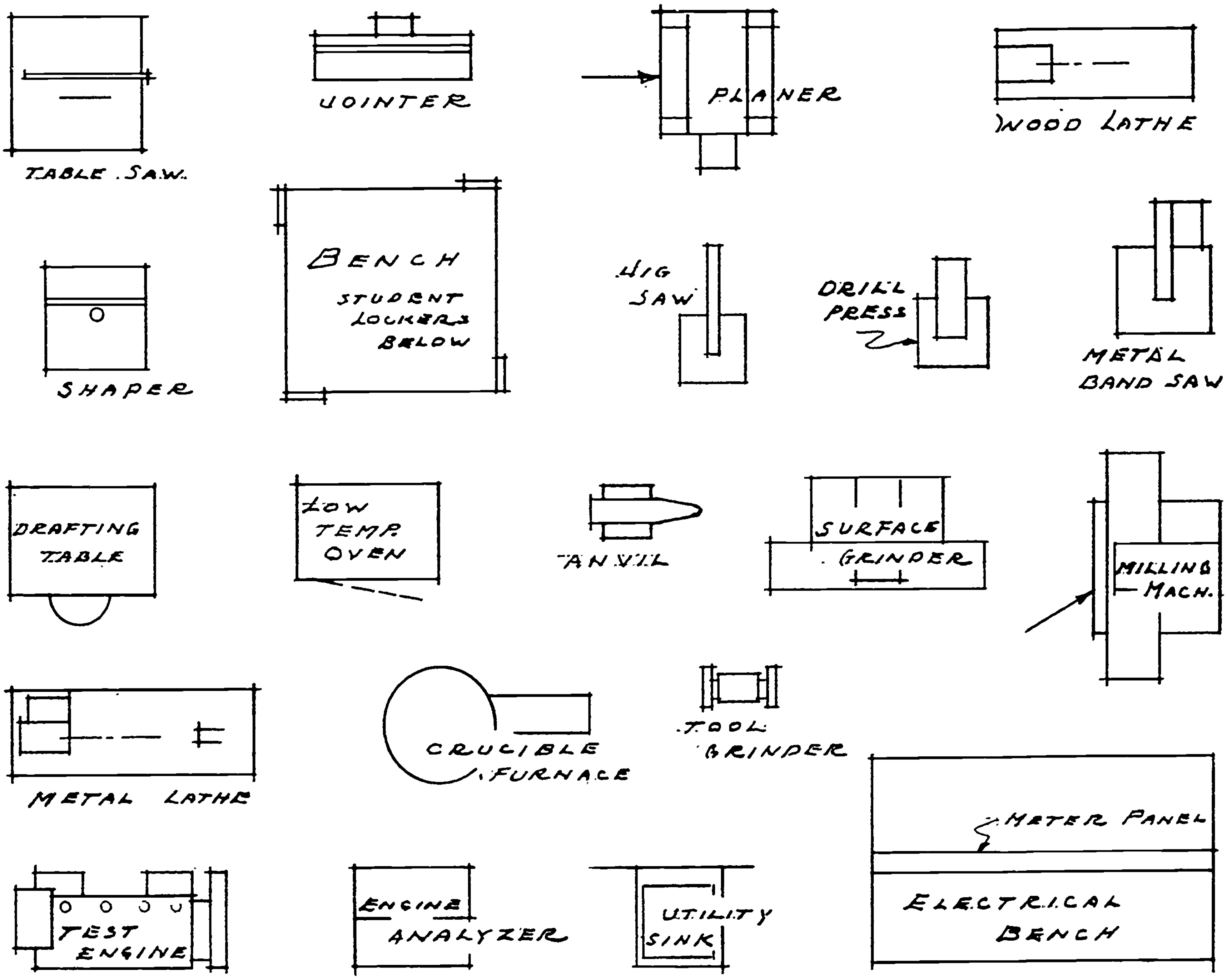

Fig. 5-1 Standard representations for equipment on layouts drawn to a scale where 1/4 inch equals one foot.

4. Position equipment to provide for safe operation by the operator and also protect other students in the class. For example: The circular saw must be located so that a piece of stock "kicked-back" will not endanger other students in the shop.
5. Arrange machines that have related operations in such a way that the proper sequence of work can be easily followed with a minimum of student and material movement.
6. Arrange band saws, drill presses, surface grinders, and other tall equipment so that visual control throughout the shop will not be obstructed.
7. Provide distinct aisles of travel between major areas and points of common usage, such as planning areas, tool centers, storage areas, supply centers, and shop entrances and exits. These aisles of travel (traffic lanes) should be at least four feet wide for primary traffic and two-and-a-half feet wide for secondary traffic.
8. Arrange individual work stations, supplementary work stations, tool panels, and supply centers so that the processes and operations of a given activity can be carried out by the student with a minimum of travel through the shop.
9. Provide extra space around lockers, entrances, tool panels, wash basins, and other areas where traffic will be heavy or where students may tend to congregate. (Student lockers and washing facilities might be lo-

cated in several places to prevent congestion at the beginning and end of the work period.)

10. Position machines, benches, and tables so that the major light source will be correct for the work. For example: The major light source should be located in front and to the left for the "right-handed" worker at the drawing board.
11. Group machines and equipment that have similar requirements for dust collection, ventilation, or power. For example: Locate forging, foundry and welding equipment under one hood, and woodworking equipment so that a dust collector can serve several machines without excessive duct work.
12. Provide working surfaces adjacent to such machines as drill presses, jointers, and table saws where multiple work pieces can be stacked.
13. Position and arrange equipment so that it can be easily cleaned, maintained, and serviced.
14. Position equipment with hazardous moving parts so that the possibility of accidents is minimized. Modern power equipment will usually have adequate shields and guards which may reduce the importance of this consideration.
15. As equipment and work stations are located, be certain that special features necessary for safe and efficient operations are included and *shown on the drawing*. For example: Arc welding must be confined to a carefully designed booth since the "flash" is harmful to the naked eye. Adequate ventilating hoods are also essential.

While working with the equipment layout, the industrial arts planner should try to visualize the shop in actual operation with the students entering the shop at the beginning of the period; securing tools and project materials; working at benches and machines; moving to stock rooms, supply centers, and other supplementary areas; listening to lectures and observing demonstrations; moving through the shop during the clean-up period; and leaving the shop when the class is dismissed. The experienced instructor can do this without much difficulty and can usually make important refinements by following such procedures.

Some planners have found it helpful to make a tracing paper overlay of a proposed equipment layout and then to draw two-foot (scaled) circles at each work station (see Figure 5-2). After completing the overlay, he can sketch in and study primary and secondary traffic lanes. This procedure will often reveal points of congestion and inadequate floor area allowances. It is usually impractical to incorporate any of this study in the finished drawing, since it may complicate the equipment layout and obscure important details.

As the equipment layout is developed, decisions concerning the amount, type, and size of major pieces of equipment must be made. These decisions should be based on adequate educational plans. Class sizes and the content of the industrial arts courses will indicate to a large extent the amount of equipment and the number of work stations required. Final selection of make and model should be made when equipment lists are prepared.

One of the common errors in school shop planning has been the inclusion of too much equipment. Many so-called "sample" plans show an array of equipment with little space remaining for the student. If each machine, bench, and table is recognized as a work station and it is understood that a work station consists of floor area for the operator as well as the equipment, then the planner will be less likely to develop layouts that are overcrowded.

After a satisfactory solution for the equipment layout has been developed, a carefully made finished drawing should be prepared. The accuracy and quality of the line work and lettering should demand the respect of the architect and others who may refer to it. Current practice suggests that machines and equipment be identified by placing descriptive names on each individual piece or group. Tabular forms of identification are more difficult to read and the space-saving feature is not required for a drawing of this type and size.

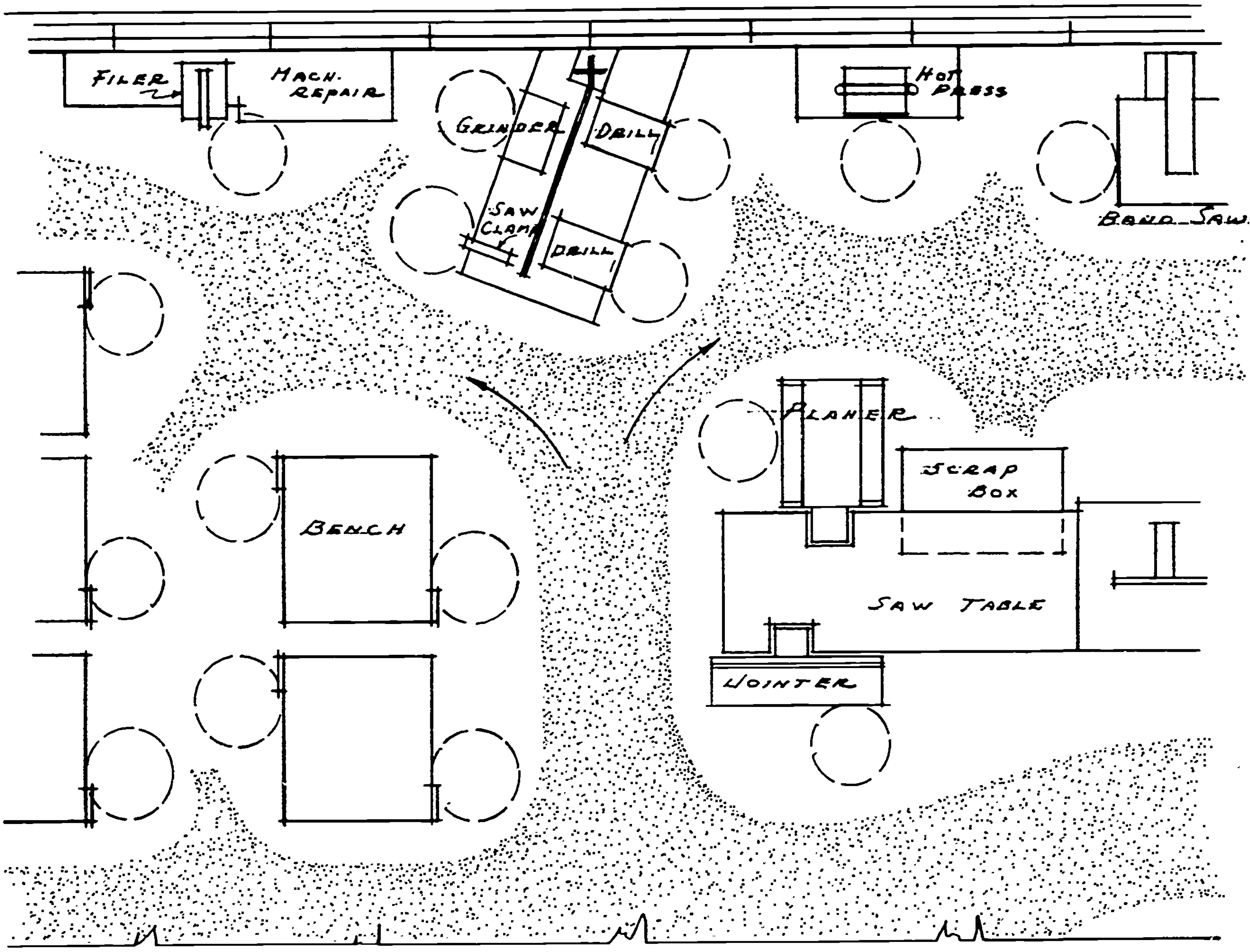

Fig. 5-2 Circles are used to represent students at work stations. Shaded area denotes traffic lanes.

Chapter VI

DETAIL DRAWINGS AND INSTRUCTOR'S SPECIFICATIONS

In addition to the equipment layout which shows locations and arrangements, the architect and his staff will need information concerning general size and design requirements for cabinetry and other built-in construction. The industrial arts instructor-planner can best present his ideas in this area through the use of detailed drawings and sketches attached to the equipment layout.

Today the residential designer makes extensive use of storage walls, wardrobes, cabinets, and other fixtures that are convenient and result in favorable space utilization factors. Industrial plants are able to attain their high levels of efficiency largely because of well-designed storage and handling facilities. Likewise, the modern industrial arts shop must include carefully designed storage cabinets, tool panels, stock racks, and other built-in features that will insure the best use of available space and provide effective instructional facilities.

Any cabinet, rack, or panel that is permanently attached to the floor, wall, or ceiling is generally considered to be a part of the building. Their design and specifications should be included in the working drawings so that they can be constructed as a part of the general contract. Movable racks and cabinets, unless otherwise specified, are not included in the plans but are purchased as equipment along with benches, machines, and tools.

The industrial arts instructor should make a careful analysis of the needs in this area and then suggest designs and describe requirements. The architect will prefer drawings or sketches that are not highly detailed and which show only over-all dimensions, general proportions, and the location of doors, drawers, and shelves. This will permit more flexibility as he adjusts his work to that in other departments or adapts it to standard sizes of prefabricated millwork. Examples of drawings of this type are shown in Figures 6-1 and 6-2. Statements concerning the quality of materials, construction, and finish can be included in note form on the drawings or included in the instructor's specifications.

The materials and workmanship represented in these built-in units and other inside wood and metal trim must be of excellent quality. The importance of this must be emphasized, because they will to a considerable degree serve as standards and examples for the students enrolled in industrial arts classes. It will be exceedingly difficult to secure high-quality work from students who are surrounded by racks and cabinets that are poorly designed and constructed from inferior materials.

Occasionally some of this construction has been undertaken by advanced students enrolled in the areas of woodwork and metalwork. Such a procedure may be justified when the jobs are small, when they will not disrupt other classes, and when the experience gained from the work will fit into the instructional program. In the planning of a new shop or a major revision of an existing shop, it is advisable to include all of this work in the general contract.

Instructor's Specifications

Some detailed requirements and needs can be easily and effectively presented in a written form usually referred to as the "instructor's specifications." They are an important supplement to the graphic materials and provide organized information for the architect as he prepares the working drawings and specifications.

It is not necessary for the information to be fully detailed with complete technical data comparable to regular building specifications. For the most part the architect will prefer concise descriptions, with the items consisting mainly of special requirements beyond the usual recognized standards. Specific information should be given relative to such items as motor types and sizes, as well as requirements for gas-fired equipment. Listed below are some of the areas that should be included:

1. *Electrical requirements for major equipment and appliances.* Include horsepower or wattage ratings, voltage, and type of current. Suggest location of master-control panels if not shown on equipment layout. Suggest the location of special convenience outlets and prescribe the three-prong grounded type.

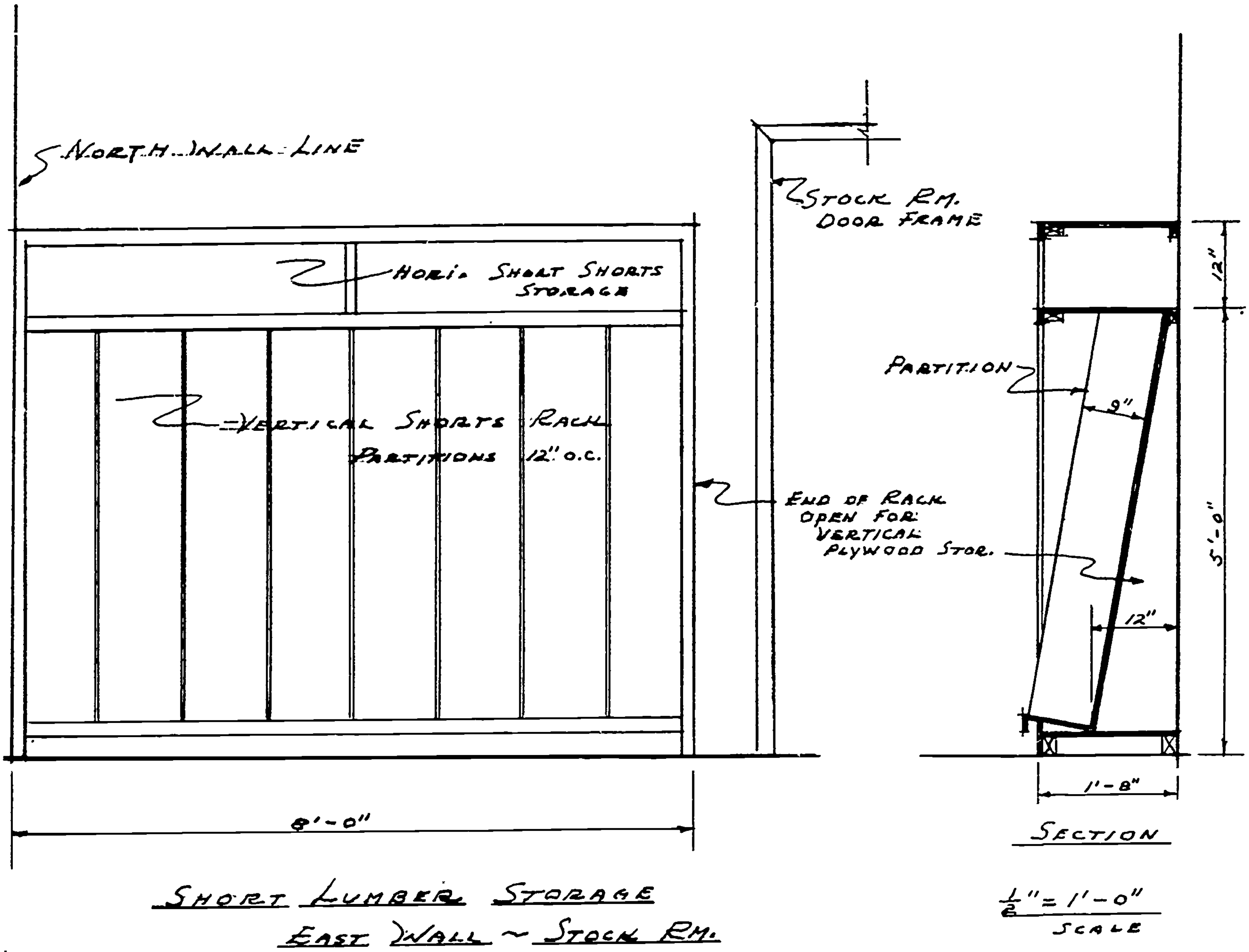

Fig. 6-1 Detail drawing of a stock room rack that will be submitted to the architect.

2. *Fuel requirements for furnaces, forges, and ovens.* Provide BTU rating and other requirements specified by the manufacturer of the equipment. Suggest the location of a master shut-off valve.
3. *Special plumbing requirements.* Include such items as sink drains, quenching tanks, hot presses, spray booths, and engine cleaning equipment.
4. *Special requirements for heating and ventilating.* Include hooding requirements for forging, foundry, and welding; exhausts for spray booths; and humidity requirements for lumber storage rooms.
5. *Compressed air requirements.* Suggest location of compressor and outlets. Describe equipment that will be operated and volume and pressure required.
6. *Welding booths, spray booths, and dust collectors.* These items and similar equipment that will be included in the general contract should be listed and described.
7. *Special lighting requirements.* Describe requirements for bulletin boards and display cases. Include explosion-proof fixtures for finishing areas.
8. *Chalk boards and bulletin boards.* Recommend size, spacing, and general specifications for chalk boards, bulletin boards, and built-in projection screens. Describe location if not shown on equipment layout.
9. *Shelving and cabinets.* Describe requirements for these and various built-in fixtures if not fully shown in detailed drawings. Prescribe material, quality of construction, and finish.
10. *Working surfaces.* Describe requirements and

recommend materials for counter tops and working surfaces of built-in equipment.

11. *Locks and keys.* Recommend type of locks and keying pattern for lockers, drawers, and storage facilities.

12. *Floors, walls, and ceilings.* Recommend the type of floors for various areas; list desirable characteristics of wall and ceiling finish; and suggest color preferences.

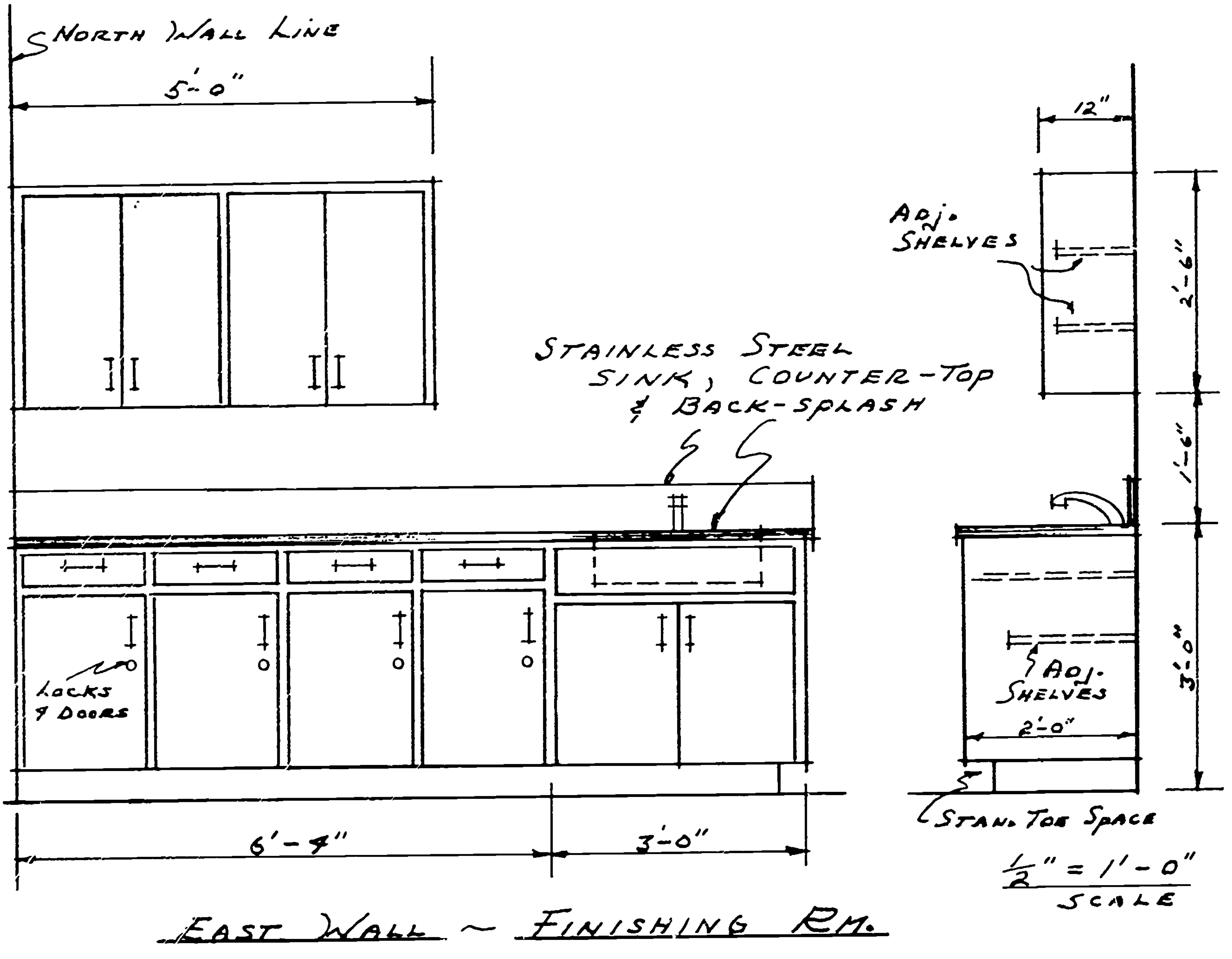

Fig. 6-2 Detail drawing of a sink and wall cabinet for a wood and metal finishing room.

Chapter VII

GENERAL STANDARDS AND RECOMMENDATIONS

Location

Industrial arts shops should be located on the ground floor and preferably at the end of a wing of the main building. This will permit the use of windows on at least two sides of the shop, which is usually necessary in order to provide adequate natural light for the larger room sizes that are required. Such a location can also provide access to the service driveways of the school plant so that heavier materials and supplies can be received without an excessive amount of handling.

If the industrial arts program includes areas of power or auto mechanics, an overhead drive-in door should be included in the plans. This door should open onto a concrete surfaced area which can be used for automobile service work or large construction projects during favorable weather. It is considered good practice to segregate this work area from the main campus or school grounds through the use of wood or masonry walls and/or planting and shrubbery.

Locating the school shop in a separate building has not been highly recommended in the past because of the tendency to separate industrial arts from the regular school program, as though it were something special and different. The acceptance of a cluster or campus type of plant layout, where considerable separation exists among various instructional programs, has minimized this objection.

When an extensive program of evening adult education classes is anticipated in the industrial arts area, it would be important to locate the shop in such a way that it can be made available without opening or lighting a large part of the main school plant. A parking area located adjacent to the building access that will be used by these students, is also desirable.

Shape

Square, hexagonal, or even circular shapes may be appropriate for the general form of an industrial arts shop. However, because of limitations imposed by structural support and economical requirements, this shape usually will take the form of a rectangle. The length of the rectangle should not exceed twice its width and only in very small shops should this width be less than 30 feet.

A prime factor in this consideration suggests that the shape permit effective grouping of the instructional areas with a minimum amount of travel by the student as he carries on his work. It is also important that the shape is such that the instructor will be able to maintain a high level of "visual control" from any position in the shop.

Except for long narrow designs and those that have awkward angles or obstructions that prevent flexibility in their use, it is difficult to prescribe or eliminate any particular shape.

Partitions and Walls

In order to maintain a high factor of flexibility, partitions in the school shop should be non-bearing walls that are as free as possible of heating and plumbing installations. In many situations a lightweight metal partition, insulated to minimize sound transmission and with clear glazing from a 42-inch height to the ceilings, has proved to be satisfactory. Double glazing may be required where high levels of sound control must be maintained.

Wall surfaces from the floor to a height of 4 to 5 feet should be of a non-porous material with a light reflective factor of about 40 per cent. Glazed brick or tile in light tones has acceptable characteristics and is commonly used. Metal panels and composition boards that have tough baked enamel finish are easy to clean and are available in textures and colors that have desirable visual qualities.

Sheet linoleum, vinyl materials, and plastic laminates provide excellent surfaces in most areas except forging, foundry, and welding. In offices and drafting rooms, prefinished plywood panels are especially appropriate, presenting a warm, attractive appearance along with satisfactory levels of durability. A somewhat less expensive alternate for these materials and one that is practical for nearly all areas is a plastic coating often referred to as "vitro-glaze." It can be sprayed over common brick, concrete block, or plaster and provides a hard, impervious surface that is long lasting and maintenance free.

Upper walls from the wainscot or dado to the ceiling should have some sound-absorptive qualities with a surface that can be easily maintained. Flat or matte finishes that provide a light reflective factor of at least 60 per cent are recommended.

Floors

Special consideration should be given to the selection of floors for the school shop. In general, they may be evaluated on such characteristics as:

1. Strength and rigidity
2. Surface texture
3. Light reflection factors
4. Sound-absorption qualities
5. Durability
6. Fire resistance
7. Appearance

It is also important for shop floors to be level and to lie in a true plane.

Requirements will vary for different types of activity. For example: Floors for forging and welding must be fireproof while those in finishing areas should resist the action of paint solvents and should provide a surface that can be easily cleaned.

In modern one-story construction, floors often consist of a concrete slab laid directly on the grade. This type is satisfactory for the school shop if it has been laid on a waterproof membrane which permits the use of a variety of floor coverings. In northern climates a perimeter insulation strip should also be incorporated.

Bare concrete floors are acceptable for areas of metalwork and power mechanics, provided they are reinforced, level, and have a carefully troweled finish. A sealer or hardener should be applied to prevent "dusting" and to reduce the porosity of the concrete. These treatments, however, must not result in a "slick" surface that will constitute a hazard to those working in the shop. Around dangerous equipment an abrasive-surfaced concrete will provide better footing. If sufficient traction is not provided in the basic floor, then an overlay of rubber matting or a special coated abrasive (Ferrox) should be applied to the surface.

Wood floors of oak, maple, or birch are very satisfactory for nearly all of the activity areas except hot metalwork and power mechanics. They should be carefully laid and finished with a material that will not become slick with wear. Precautions similar to those suggested for concrete floors should be observed. Paraffin-impregnated end-grain blocks have proved to be an excellent flooring material for many industrial arts activities, since they possess nearly all of the desired characteristics except fire resistance. End-grain blocks that are not impregnated but which are surface coated after being laid are satisfactory if sufficient allowance is made for expansion and contractions.

Resilient floor coverings, such as asphalt tile, rubber tile, vinyl tile, vinyl-asbestos tile, and linoleum, are very appropriate in the areas of drawing, woods, electricity, bench and sheet metal, and graphic arts. Commercial grades are recommended, and they should be selected in light color tones with reflective factors of at least 30 per cent. In the school shop, tile should be laid in a continuous pattern. Elaborate designs or contrasting "checkerboard" patterns should be avoided.

New types of floor coverings are continually being developed, and many of them will have characteristics that are desirable in the industrial arts shop. For example: A cork tile with a special plastic binder has recently been developed to sell at a competitive price. It combines the softness and resiliency of cork tile with the permanence of a tough plastic surface. Today wall-to-wall carpeting is used extensively in commercial and institutional buildings. Its use in school drafting rooms and offices would be exceedingly appropriate.

Ceilings

Although general recommendations for industrial arts shops usually suggest a minimum ceiling height of 12 feet, improvements in mechanical ventilation and artificial lighting now make it possible to secure a satisfactory environment under a ceiling as low as 10 feet. Where natural light is desired throughout large shop areas, "clerestories" or "skydomes" can be used in single-story construction.

Ceilings in shops should be finished in the same manner as other classrooms in the building. Unfinished ceilings with exposed joists are unattractive and difficult to decorate and maintain. In addition to this, they usually have unsatisfactory sound-absorption and light-reflection factors. Furred and finished ceilings are desirable according to Educational Facilities Laboratories because they provide:

1. Space between finished ceiling and framed deck in which to run pipes, wiring, and ducts.

2. Cheap insulation of air space if there is a roof above.
3. Level unbroken surfaces, to which to apply finish, to space lighting fixtures, and to serve if so designed, as a light reflector.
4. A finished appearance.
5. Furred ceilings of plaster or fire code plasterboard will sometimes add one-half to one-hour fire resistance to unprotected steel framing, which is rated at no resistance at all.(I)

General recommendations for shop ceilings suggest that the finish provide a light reflective factor of at least 80 per cent and a minimum noise reduction coefficient (N.R.C.) of .35. There are many types of materials available that will meet or surpass these requirements. Perforated or slotted composition boards are recommended, since their sound-absorption qualities are not greatly affected when they are painted. A very satisfactory finish can be obtained through the use of light-gauge metal panels that are perforated and enclose a mineral-fiber sound-absorbent pad. They are easy to clean and are rated as "incombustible" — two very desirable characteristics for surfaces in the school shop.

Doors and Windows

At least one shop entrance should be large enough to permit easy entry of the largest piece of equipment and removal of the largest project that will be constructed. Careful planning in the location of entrances will permit the maximum degree of flexibility in their future use as the location of partitions within the shop is changed and adjusted. In general, main entrances should be located along a side wall rather than an end wall.

Passage doors for drafting rooms, finishing rooms, and other instructional areas need to be at least 3 feet wide and need to open outward with the natural flow of traffic. These doors must be fitted with safety latches that cannot be locked against egress. Doors to stock rooms, supply rooms, and tool rooms may be smaller and may open inward; however, they, too, should be equipped with safety latches.

Although natural light is variable and presents many control problems, some windows are considered desirable in the school shop. Large window areas can result in high solar-heat gains while the sun is shining and excessive heat loss when it is not shining, thus making it difficult to maintain a desirable thermal environment.

Windows that are shaded from direct sunlight by exterior shades or slatted overhangs provide the best source of natural light, since they eliminate to some degree the need for interior shades and blinds. Even though dust in the shop should be carefully controlled, the problem of maintaining interior shading devices will be greater than that required in a more conventional classroom.

When possible, windows should extend to the ceiling to give better distribution of natural light throughout the room. High windows with sills about 5 feet above the floor will usually permit greater flexibility in equipment arrangement. Windows of conventional height should have inside sills (stools) that are narrow or sloped so they will not serve as "catch-alls."

Lighting

Due to the broad range of brightness-contrast that exists among the many and varied tasks that are a part of the typical industrial arts program, adequate lighting is of paramount importance and must be given equal or even greater consideration than that in any regular classroom.

Minimum light intensities should not fall below 60 foot-candles at bench height in any of the work areas. At precision work stations this intensity may need to be supplemented with some type of localized lighting. The quality of the lighting, however, must always be recognized as being of equal or even greater importance than intensity.

> "Although a highly important element, the foot-candle or level of lighting is no longer the recognized measure of lighting efficiency. It is now well understood that foot-candles (the amount of light on the task) alone do not determine how well one sees.
>
> "The concept of brightness-balance stresses the correlation of values of brightness differences and brightness patterns with values of lighting levels and varying tasks. It has become accepted as the informed approach to the design of an acceptable visual environment for schools."(II)

(I) *The Cost of a Schoolhouse.* Educational Facilities Laboratories, Inc., 477 Madison Avenue, New York 22, New York, 1960, page 103.

(II) National Council on Schoolhouse Construction, *Guide for Planning School Plants,* published by the Association, Michigan State University, East Lansing, 1964, page 121.

Brightness-balance refers to the control of light emitted or reflected by all the objects and surfaces in the total visual field. Standards require that brightness-differences between the task and surrounding area be kept at a low level.

The National Council of Schoolhouse Construction recommends that: the brightness of any object or surface in the visual field should not be greater than 10 times the brightness of the task; the lowest acceptable brightness of any object or surface in the visual field should not be less than one-third the brightness of the task; the surface immediately adjacent to the visual task should not exceed the brightness of the task; and the brightness-difference between adjacent surfaces in the total visual field should be reduced to a minimum.

If these goals are approached, lighting systems must be designed to provide even distribution throughout the shop. Semi-indirect fixtures, spaced closely together, provide a nearly uniform ceiling brightness which will result in well-diffused lighting, thus reducing glare and shadows. Highly satisfactory results have recently been attained with direct systems that employ luminaires equipped with polarizing panels.

Since the brightness of a surface is the product of the light intensity times its reflective factor (foot-candles $\times$ reflective factor $=$ foot-lamberts), the color and texture of the finishes on benches, cabinets, machines, and other equipment should be selected with great care.

Providing a satisfactory visual environment in the classroom and the school shop is such an important matter, and so highly technical in nature, that the services of an expert in the illumination field should be secured whenever a new system is being designed or an old system is being remodeled.

Color

Consideration of color treatments for the industrial arts shop can be approached from the viewpoint of the environment created as well as an aid to maintenance. In the past, color selections were often based on the latter which resulted in drab shades of cream, brown, and gray.

Numerous studies have shown that the proper selection of colors can aid the student in doing better work with less mental and physical strain. Psychological effects must be recognized as color schemes or painting schedules are developed. In general, greens, blues, and aquamarines are restful colors, while red and orange are stimulating and may be irritating under certain conditions. Yellows are considered to be exhilarating; browns and grays, depressing.

New developments in the field of synthetic resins have led to the production of finishes that possess excellent color retention, durability, and heat resistance. They are available in a wide range of colors and provide a soft-sheen effect that is very helpful in producing a pleasant visual environment.

Furniture, benches, and built-in equipment, constructed of a light-colored hardwood with a clear finish, provide a very durable and attractive surface. Light tones of buff, gray, blue, or green are good colors for machines and equipment that require paint. When possible, colors should be selected that provide some contrast with the material that will be worked.

The use of bright focal colors on controls and points of danger on equipment and machines provides a safer environment as well as an attractive appearance. The following is a portion of the *Safety Color Code* approved by the American Standard Association and the National Safety Council.

RED — Used to identify fire protection equipment. Area around or behind such equipment is painted in a red square.

ORANGE — Used to designate dangerous parts of machines such as guards, cutting edges, gear boxes, open belts, etc.

YELLOW — Used on construction equipment, coverings or guards on hazardous equipment, ceiling-suspended units, and inside covers of switch and fuse boxes. Yellow, striped with black, is used on handling equipment, traveling conveyors, and low beams in operating areas.

GREEN — The basic color for safety units and first-aid equipment. Used on stretchers, first-aid kits, gas masks, safety bulletin boards, etc.

WHITE — The sanitation color. Used on refuse cans, fountains, and food-dispensing equipment. Also used in corners of dark passageways, stairways, etc.

PURPLE — Warns against radiation hazards. It is used on doors leading to dangerous areas and on receptacles for radioactive materials.

Sound Control

Because work in the school shop includes an array of noise-producing activities, sonic engineering should be applied to this area with an emphasis at least equal to that which is currently given to music rooms, gymnasiums, and auditoriums. Unwanted sound (noise) is distracting and annoying, reducing the efficiency of both the students and the instructor. If not controlled, it can become an important deterrent in the safe operation of machines and equipment. Excessive noise will require the instructor to talk loudly in order to be understood, thus producing tension and fatigue in himself as well as his students.

The source of unwanted sounds should be minimized as much as possible. This requires the selection of well-designed equipment that is kept sharp (planers, jointers, and saws become very noisy when dull) and otherwise carefully maintained. Such equipment as anvils, stake-plates and machinists' vises will require heavy benches and mountings. Chimes are a pleasing substitute for the noisy bells and buzzers used to announce clean-up periods and to call the class together for demonstrations.

Proper orientation of the various instructional activities should separate those that produce noise from the quieter ones. Glazed partitions may be necessary to further isolate a noisy area. The transmission of sound can be minimized by mounting machines and equipment on rubber or composition pads (they should never be mounted on columns or other structural members of the building). Heating and ventilating ducts transmit sounds and may require special treatment.

The sound-absorption qualities of floors, walls, and ceilings will greatly affect the shop environment. Such materials as concrete, glass, and plaster reflect approximately 95 per cent of the sounds that strikes them, while wood, cork, and composition materials will reflect a much lower percentage. Acoustical materials for upper wall and ceiling finish in the school shop should have a sound-absorption coefficient of .60 or higher. The sound-absorption coefficient (also called a noise-reduction coefficient) of a material is defined as the fractional part of the energy of a sound wave that is absorbed at each reflection.

The location of an acoustical material is highly important and should receive as much attention as the type of material used. It has been found, for example, that several rows of acoustical tile along both the wall and ceiling at the corner where these surfaces meet may be more effective than covering the entire ceiling and disregarding the walls.

Sound control, like lighting, is a highly technical consideration and help from an expert in the field of acoustics should be secured.

Heating and Ventilating

Since the industrial arts program consists largely of an active, participatory educational situation, the heating and ventilating standards vary somewhat from those in the regular classroom.

The heating system should automatically maintain a temperature of 68 degrees Fahrenheit, measured at a height of 60 inches above the floor. Drawing and planning rooms will require a temperature of 72 degrees. Recommendations state that the maximum temperature gradient from the floor to 60 inches above the floor should not exceed three degrees. Relative humidity in the shop and storage areas should not be permitted to drop below 30 per cent in the winter months or rise above 60 per cent during the summer months. This includes consideration for the health and comfort of the students and instructor as well as for the stability of equipment and materials.

General ventilating requirements suggest that a mechanical system provide a minimum of 15 cubic feet of air per minute (CFM) per student. This will equal about two or three complete air changes per hour in the average shop, and is sufficient if there are special provisions for hooding and venting all equipment that produces dust, smoke, vapors, and fumes.

Finishing rooms should have separate ventilating systems with exhausts that flow directly to the outside. If spray finishing is included in the methods of application, a spray booth with a face velocity of at least 125 FPM must be included. Provision for "intake" air must be made, either filtered air from the main shop or heated air from outside.

A carefully designed hood and mechanical exhaust system is essential for welding, forging, and foundry areas. This installation is directly connected to health and safety and should be planned and installed by an expert.

Dust collection equipment must be provided for metal grinders and such power woodworking machines as planers, jointers, saws, and sanders. A central system with ducts running from each machine to a single fan and filtering device is highly efficient and requires a minimum of service. The system should include floor "sweep-ups" and ducts running to several locations throughout the shop where vacuum cleaning attachments can be connected.

In small shops where a central system cannot be justified, equipment layouts should include self-contained unit dust collectors that can service individual machines or several machines grouped together.

Heating systems that are satisfactory for the conventional classroom will usually fill the needs of the school shop. Floor or ceiling radiant panels are ideal, since they will not interfere with equipment arrangements. Industrial-type unit heaters that are suspended from the ceiling and depend on a heavy blast of air to circulate the heat are undesirable because the high velocity of the air is noisy and uncomfortable, and also carries excessive amounts of dust and dirt throughout the shop. Standards suggest that general air movement should not exceed 25 lineal feet per minute during the heating season. This limit may be extended to 100 FPM during mild weather.

Electrical Power

Since modern industrial arts shops include so many machines, tools, and equipment that are powered by electricity, it is essential that an adequate wiring layout be provided. The years ahead will bring new machines that will perform new processes and the electrical load will continue to mount. Consequently, the electrical system should include an oversupply of circuits or conduit and distribution panels large enough to permit easy installation of additional wiring.

All electrical installations must be made according to the National Electrical Code, with power equipment and machines grounded and all convenience outlets of the three-prong grounded type. Pilot-light indicators must be provided for equipment that employs electrically heated elements.

Power conduits or ducts that provide single and three-phase current should be located in the floor with access boxes that have flush caps. Three-phase current is usually recommended for motors over ½ horsepower. Requirements suggest that wall-mounted convenience outlets be located a minimum of 10 feet apart and 42 inches above the floor.

Main electrical distribution panels should be centrally located and convenient to the instructor's office. They should be of the shock-proof, metal-clad type, and equipped with automatic circuit-breakers and locks. Recent standards suggest that an emergency pushbutton shut-off be provided in two or more strategic locations throughout the shop.

For maximum safety, each machine should be equipped with a magnetic overload switch that is operated with a pushbutton. This type of control requires the machine operator to go through the starting cycle whenever the power has been interrupted.

General lighting control should be located outside the distribution panel. Safety lighting, alarm, and bell circuits must be taken off the main line ahead of the main service switch.

Plumbing, Water, and Gas

Sinks are needed in several areas of the industrial arts shop. Hot and cold water are essential at fixtures used for cleaning equipment, mixing materials, or handwashing. In metalwork, a low-mounted utility sink is best for "quenching" and cleaning equipment and work pieces. Sinks in drafting rooms and finishing rooms should be installed in cabinets with appropriate types of counter tops and organized storage space below.

In addition to these "work" sinks there should be a central washing facility, consisting of either a half-round or trough-type sink, large enough to accommodate about one-fourth of the largest class at one time. Faucets that supply tempered water and are foot-pedal operated are highly recommended.

Grease and sand traps should be provided in floor drains, finishing room sink drains, and any others that may serve some special purpose.

A drinking fountain of an approved type, centrally located in the main shop area, should provide clean, cool water. The fixture may include individual mechanical cooling equipment or connections to a central water cooling unit.

Gas service will be needed in the metalwork area for blast furnaces, forges, and soldering equipment. Supply lines that provide BTU inputs that are considerably greater than the initial equipment requires will allow flexibility in future expansion and revisions. Even though all appliances are equipped with a safety-pilot system which automatically shuts off the gas if the flame goes out, it is still a good precaution to install a master shut-off valve for emergency use, one that is located some distance from the equipment.

Compressed air service is needed for spray painting in the finishing room and for the operation of modern portable air-driven tools in woodwork and metalwork. Equipment used in auto mechanics may also require compressed air. Outlets should be distributed throughout the areas that require this service. The air compressor should be located outside the shop in a tunnel or other service area of the school plant.

Tools and Equipment

Localized tool and accessory panels seem to best serve the needs of the modern general shop (see Figure 7-1). This method of tool control usually requires several panels, each of which is equipped with appropriate tools and mounted on the wall or otherwise installed adjacent to the area of activity it will serve. The panels may be designed with sliding or swinging doors that can be closed and locked.

Portable tool panels or cabinets have been successfully used in some areas of the school shop. They are usually mounted on large casters so that they can be easily rolled into the work areas during the class period and then returned to a storage or supply room at the close of the period or school day. Panels of this type may offer special advantages when the shop is set up for a mass production project during a part of the school term.

Auto mechanics and machine tool shops or areas present special problems in tool control because of the size and value of some of the items. Centralized tool rooms may often be justified, or a combination of localized panels and a central tool room can be used. In these areas, kits of basic tools are often established and checked out to each student for the duration of the course.

In the past, industrial arts instructors have usually designed and built with the aid of their students the tool and accessory panels and cabinets for their shops. Today, however, with larger classes and expanding course content, it seems more practical to include these panels in the general building contract. The industrial arts instructor should continue to determine the size and design; many will prefer to also maintain the responsibility of building and mounting the tool holders.

The design of a tool panel will be determined to a large degree by the type of tools and equipment it will hold. For example: A panel for electrical tools might include special compartments to hold expensive meters or test equipment. These compartments could be enclosed with sliding plate-glass doors that provide security and permit convenience in making a visual check.

Tool panels and cabinets should always be constructed of a good quality hardwood or heavy gauge metal, with a durable finish and appropriate hardware. Carefully designed and constructed tool holders like those shown in Figure 7-2 are recommended. Patented hooks or clips are seldom satisfactory. A good tool holder should fill the following requirements:

1. Holds tool in one position. Preferably, this position should be secured without having to revolve or change natural holding points.
2. Holds tool securely and protects it from damage and also protects students.
3. Mounted on a sub-panel so that the tool will not contact and damage the main panel.
4. Easily cleaned and maintained.
5. Attached to tool panel with screws to facilitate replacement or rearrangement.
6. Includes silhouette, name, and size of tool.

Tool panel arrangements should be based on safety, usability, and appearance. For example: Tools usually can be arranged in a symmetrical or interesting pattern, with related tools grouped together, and with pointed tools and tools with exposed edges mounted well below eye level.

Instructors generally prefer to have the panel located about 2 feet above the floor with the top not more than 6 feet high. This will help eliminate dust that tends to collect in the lower levels and also provides easy access to the tools. The lower section of tool cabinets or panels can be fitted with doors or drawers to store reserve tools, portable electric tools, and supplies.

In recent years, ready-built tool cabinets have become available through suppliers and manufacturers of industrial arts equipment. Their use is recommended when they are carefully selected and special attention is given to size and function.

Storage for Materials and Supplies

Activities in a modern industrial arts program involve the use of hundreds of kinds and types of material. Important learning activities can be experienced by the student in the receiving, storing, and distributing of these materials in a realistic industrial-like atmosphere, where attention is given to safety, conservation, and efficiency. Such an atmosphere can be developed only when needs are carefully analyzed and used as a basis for specifying storage facilities.

Storage areas in school shops have often been inadequate because preliminary plans became stabilized and "set" before sufficient thought was given to storage needs. The industrial arts instructor-planner must include storage requirements in educational specifications that are based on a careful study of the instructional materials and supplies needed in the operation of his program. Serious errors in shop planning have often resulted from a tendency to reduce the storage area more than the instructional

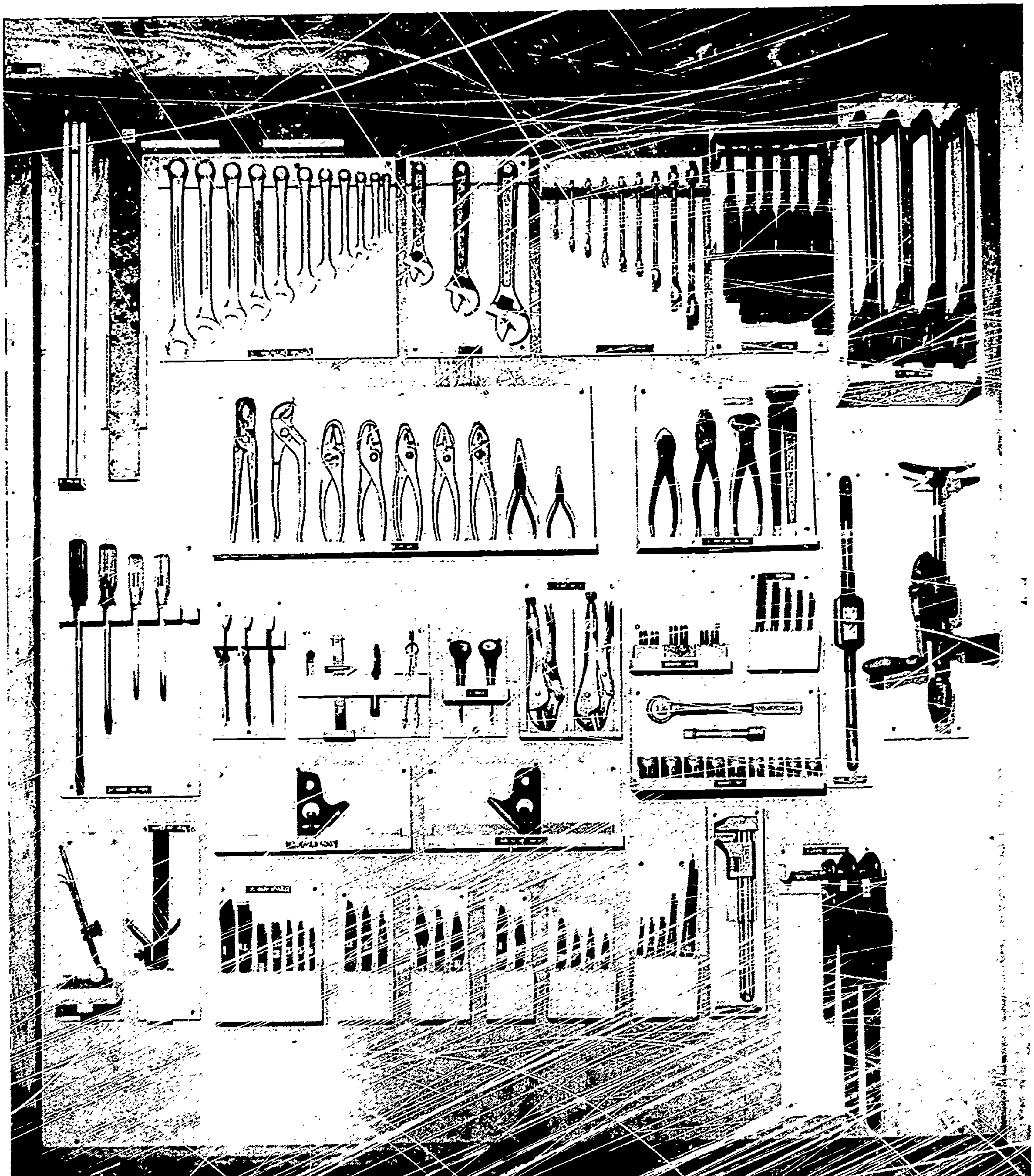

Fig. 7-1 Localized tool panel in a general metals shop.

area when "cut-backs" in the over-all plan became necessary due to rising building costs or other financial problems. Space reductions must be kept in balance, for adequate storage area is just as important as instructional area.

General recommendations for multi-activity shops where three or four basic areas are included suggest that a minimum of 15 per cent of the total floor area be allocated to storage facilities. This figure can be reduced somewhat when storage compartments are included in equipment and built-in cabinets located in instructional areas. However, it will need to be extended if full three-dimensional use of space is not accomplished through carefully designed racks, cabinets, drawers, and shelves.

The major part of the material and supply storage can best be handled in a general stock room. Some of the features in this room should include:

1. A horizontal lumber storage rack along one wall, securely fastened to the floor and structural members of the ceiling. It should not be higher than 7 feet with provision for heavier stock on the lower racks. Arms spaced 2 feet horizontally and 1 foot vertically will provide good support and considerable flexibility in handling various types of lumber.
2. Vertical racks for storing metal bar stock. These racks should have pronounced slope and guards that will prevent materials from falling out into the room.
3. Vertical compartments for storing sheet metal and plastic stock.
4. Horizontal shelves or racks for storing plywood, hardboard, and particle board. Wood-based sheet products tend to warp if stored "on edge."
5. A carefully designed rack to hold "shorts" and other small cuttings of wood and metal stock.
6. Cabinets with adjustable shelves and bins to hold bulk storage of nails, screws, bolts, sandpaper, rivets, glue, wire, electrical components and a host of other items. (Combustible materials must be stored in metal cabinets.) The size of this storage space should be determined partially by the purchasing policy of the school. Usually it is desirable to purchase these items only once a year, thus saving time in re-ordering and saving money on quantity purchases.
7. Sufficient floor area beside wood and metal racks to "rough-out" material, thus eliminating the need to transport large pieces of

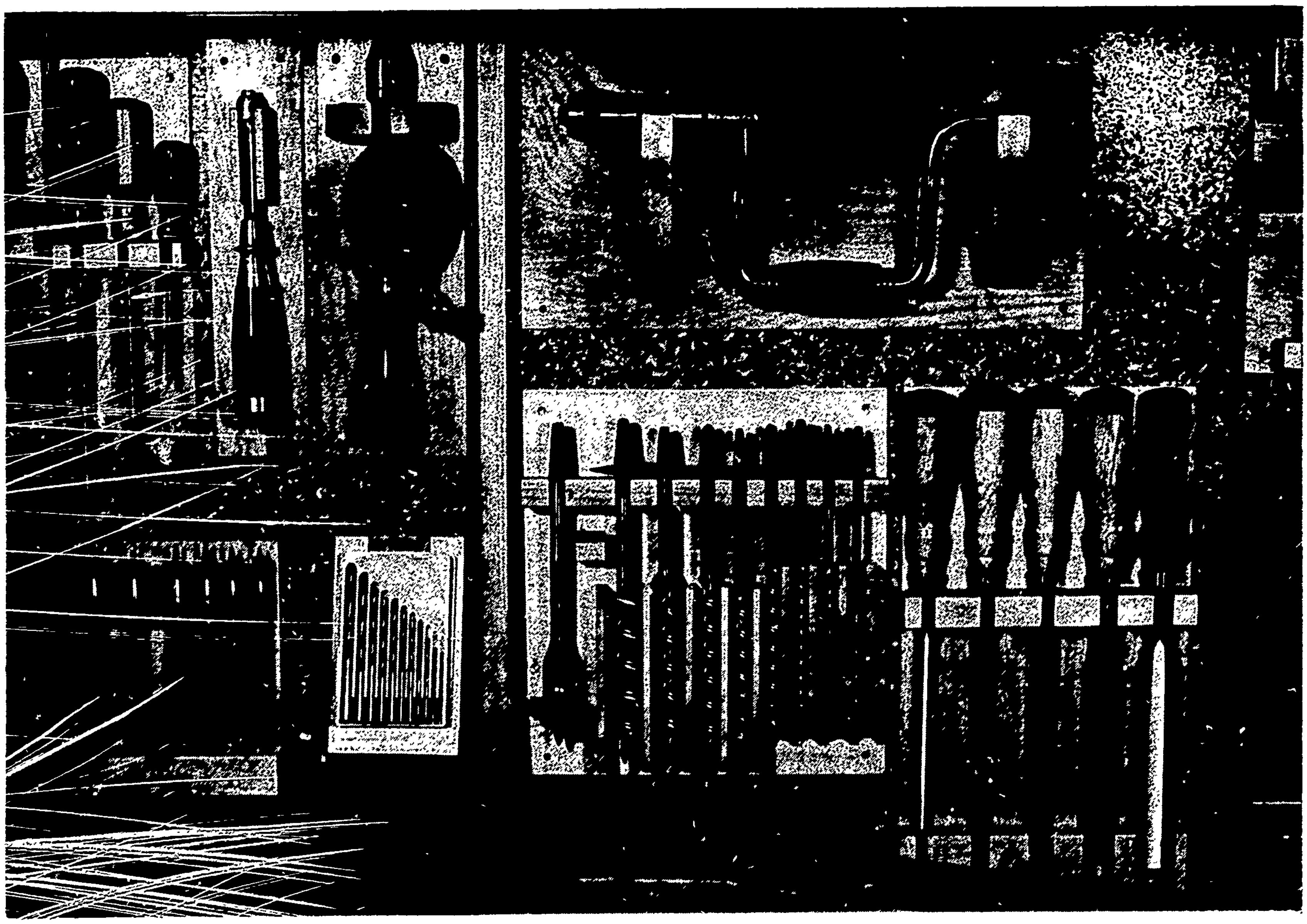

Fig. 7-2 Tool holders consisting of a small individual panel that can be easily mounted on the main panel.

stock into the main shop. A power hack saw or radial arm saw could be easily justified in this area.

Within the shop, working quantities of the various supply items should be available in the area of activity where they are used. These localized storage units may be designed in combination with tool and accessory panels or cabinets. For example: Small drawers or bins for screws, nails, dowel pins, and sandpaper could be located in a cabinet under a woodworking tool panel.

All of the above-mentioned storage facilities should be organized so that materials can be quickly and efficiently checked to determine replacement needs or shortages. Many shop instructors have developed a system of "running inventories" that insures constant attention to the amount of material on hand and that also provides an opportunity for students to share in the responsibility of operating the shop in a manner reflecting good industrial practice.

Project Storage

Each student enrolled in industrial arts should be provided with a drawer or locker, or some other type of compartment where he can store plans, aprons, pencils, small project parts, and other items. These lockers or compartments may be included in a central storage area or located in benches or cabinets in various instructional areas throughout the shop.

Some types of instructional activity will have special requirements for "work-in-progress" storage. For example: Students in auto mechanics need tote-trays that will hold disassemblies during the work period and which will also serve as a storage unit between class sessions. Electricity and electronics may have similar needs.

Woodworking, especially in advanced courses, requires considerable project storage space for sub-assemblies, assemblies, and finished products. A common solution is to provide a separate room or alcove with large open shelves on each wall so that space can be utilized vertically as well as horizontally. Sometimes the shelving is compartmentalized so that each class can be assigned a specific section which is locked or otherwise secured between work periods.

Inadequate project storage space can greatly handicap the instructional program even when all other aspects of the layout and planning have resulted in a high level of efficiency. Since items to be stored will not come into existence until after the program is in operation, it requires very careful thought and analysis to avoid errors in the planning of this important facility.

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